SPIRAL REINFORCING IN CONCRETE COLUMNS

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The Relative Strengths
of
Spiral Reënforced Concrete Columns.

A THESIS

Presented by

John J. Aeberly, Guy C. Pitts

To the Faculty of the

Armour Institute of Technology,

Having Completed the Prescribed Course of Study

in Civil Engineering.

1 9 1 3.

Alfred E. Phillips,
Prof. Civil Engineering

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Dean of Eng. Studies

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Dean of Cult. Studies.

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I N T R O D U C T I O N.

The study of the Relative Strengths of Spiral Reënforced Concrete Columns was taken as the subject of this thesis because it deals with a branch of engineering in which the knowledge is limited and because it was thought the authors could obtain considerable practical information concerning the effect on the strength of concrete mixed in larger quantities than are usually handled in the laboratories.

After a brief consideration of the publications on this subject, of such men as Professor Talbot of the Illinois University, it was decided that columns reenforced with zero, two, three and four percent of steel would give a fair comparative test of the relative strength of columns that are reënforced with such percentages of steel as are generally used in practice. As it was the purpose of this study to only consider the effect of the spiral reënforcing, the vertical rods necessary to hold the reënforcing in position were taken of such size as to make it possible to neglect them altogether and yet not materially effect the deductions taken from the experimental results.

THE WORK PRECEDING THE TESTS.

The largest size column which could be made to fit the 200,000 lbs. Riehle machine and yet have a slenderness ratio generally used in practice was a 7" x 39" column with an effective diameter of 5.5 in.

The materials which were used to make the columns were crushed Bedford limestone of about three quarters of an inch gauge, limestone screenings of the same substance as the crushed stone, Chicago A-A portland cement, cold drawn wire of such gauge as would give the required percentage of reënforcing when wound on a drum 5.5 inches in diameter to a pitch of one and one-third and cold drawn one-eighth by one-quarter bars that were used as verticals. The equipment used was a drum upon which the wire was wound, sheet-iron moulds, a Riehle 200,000 lbs. compression machine, an Olson tension machine and an extensometer device by means of which the shortening of the column per increment of load could be measured.

The work that preceded the testing of the columns may be divided into three separate parts: the building of the moulds; the making of the reënforcing; and the

mixing of the concrete, setting of the reënforcing and moulding of the columns.

The moulds were made of galvanized sheet iron that was bent in cylindrical forms; each edge in the direction of the length being bent parallel to the radius of the cylinder. The bottoms of the moulds were strengthened by short cylinders, the bottom edges of which were flared to insure a means by which the moulds could be firmly held in a vertical position. To do this, it was only necessary to mount the moulds on flat boards and to hold them fast by means of boards that were shaped to fit the cylinders and which were placed over the flared ends and screwed down. The seams of the moulds were closed by means of stove bolts and nuts which were spaced at intervals of 3 inches in the flanges that were turned out parallel to the radius.

The wire from which the reënforcing was made was wound on the five and one-half inch drum mentioned above in the same way that a person would wind a spring which would resist a pulling action; the idea being, that after enough of the wire had been wound on the drum by which a column could be

reënforced, the coil was to be removed and stretched until the pitch would be one and one-third. The vertical rods would be made to hold the bands of these coils at the required spacing by slots that would be shaped in them at intervals of three-quarters of an inch. To insure a firm hold on the wire, the edge of the slots were made to clinch the wire by throwing them inward with the aid of a hammer and chisel. This idea could only be carried out in part; it was found that owing to the increase in the elasticity which had been given to the wire by the cold drawn process, the coil would lose its shape the moment it was released. To overcome this difficulty, the wire was subjected to an annealing process. The question which may be asked at this point is, did not the annealing effect the strength of the steel? It did, yet it was so little effected that when subjected to a tension test, the steel showed a large ultimate strength.

In detail, the annealing process was carried out as follows:- enough wire to reënforce one column was wound on the drum. The ends of the wire were fastened in such a way as not to allow the tension

in the steel to be released. The drum was then placed in a furnace which was brought to a dull, red heat, after which the furnace was allowed to cool and the drum was immersed in water. It was found that when the wire was cut from its fastenings it retained, practically speaking, the exact shape to which it was wound.

The making of the vertical rods presented no difficulty. They were cut to 39 inch lengths; the spacing was marked with the use of a scratcher and a scale. It was decided that three vertical rods for each column would be sufficient, thus making twelve, the required number of vertical rods for each set of columns and thirty-six, the total number of rods required. The slots were cut just large enough to allow the wire to enter freely, the depth being a little less than .125 of an inch. The rods were clamped in the shaper in groups of twelve thus enabling in one setting, the slotting of enough verticals for one group of columns. The spirals were next stretched to fit in the slots and riveted in place by means of a hammer and chisel, the edge of the slots being made to clinch the wire.

The mixture which was used in the column was a 1;2:4,-as was said before, the materials being crushed Bedford limestone, limestone screenings and Chicago A-A portland cement. The mixing was done on a cement floor, care being taken that the ingredients were well mixed before the water was added. After the water had been added, the mixture was turned over four times, when it was placed in the moulds. Much care was given to the setting and maintaining of the central position of the reënforcing. This was carried out by the aid of three, three-quarter inch square, wooden strips that were forced between the spirals and the inner walls of the moulds. As the surface of the concrete reached the various levels, these guage strips were drawn out until the concrete was at the required level, when the strips were removed from the mould. The concrete was tamped with strips of wood of dimensions similar to those of the gauge strips, precaution being taken to force enough concrete on the outside of the reënforcing to insure a finished appearing column. It is probably well to say here that the columns were damaged in no way owing to the removal of the forms, this being due

chiefly to the fact that the moulds were well oiled and the seam could be sufficiently opened to allow a large clearance.

Seasoning of the columns which lasted for a period of five weeks was carried out in two stages: the moulds were not removed from the columns until four days after the concrete was poured into them, after which the forms were removed and the columns were allowed to dry out under a temperature of about 50° F.

T H E   T E S T.

The tests carried out under this study were of three kinds: the cement test, the test of the strength of the steel and that of the columns along with the cubes.

The cement was subjected to a fineness and a soundness test; of the four samples tested for fineness, the following are the maximum and the minimum percentages of the materials that passed a 200 mesh sieve and a 100 mesh sieve; 74.6% minimum and 76.2% maximum for the 200 mesh sieve and 90% minimum and 93.16% maximum for the 100 mesh sieve.

Under the test, the steel of different diameters showed practically the same average unit value.

The method of proceedure used in the test of the columns and the cubes was the weighing of the individual cubes and columns to determine the approximate relation of the densities, the testing of the columns with reference to the loads which they could carry and the amount of shortening which they would undergo per increment of load and the testing of the cubes to determine the ultimate strength of the

various batches of concrete used in the different columns. To determine the densities of the various batches of concrete, a mean dimension of each of three dimensions was measured for each cube or column. The solid was then placed on a Fairbanks Scale and weighed. By means of the three dimensions, the volume of each solid was determined and by dividing the weight by the volume, the density of the mass was found. This test showed that the variation in densities was less than one percent and it was, therefore, concluded that the concrete had been well mixed and that the columns and cubes were free from large sized voids.

The work preceding that of subjecting a column to a load consisted of setting the column in the middle of the Riehle machine in a truly vertical position and of fastening to the column the extensometer device. In moulding, care was taken to make the ends approximately at right angles with the axis of the columns so as to avoid eccentric stresses. A further precaution along this line was taken by placing between each end of a column in the machine several thicknesses of one-eighth blotting paper, the

paper being distributed in such a way that when the load was applied to the column it would take a position such that the line of pressure would be coincident with the axis of the column.

Before the load was applied, the rings of the extensometer device were fastened in position. These rings which were two in number were made of 1" x 1/2" steel bands formed like a hoop, 10" in diameter. One of these hoops was fastened to the lower end of the column by four set screws that butted against its surface. In the upper face of the hoop were fastened two set screws spaced at a distance of 180 degrees from each other and having their axis parallel to the axis of the column. A similar hoop was fastened to the upper end in practically the same way, the only exception being that the two set screws which were spaced 180 degrees from each other turned downward. The upper ring was so set that the extension of the axis of these set screws were made to coincide with those of the lower set screws. It will be seen that by this arrangement, we have established four points, two of which are in the same straight line each point in the line being at a distance of about 34 inches

from the other. If now we take an inside micrometer caliper and measure the two distances between each pair of points in the same line, i. e. before and after the application of the increment of load, we will obtain data sufficient to enable us to determine the unit elongation per unit load. The proceedure carried out in obtaining the data for the log sheet was, as follows:- A load of 20,000 pounds was applied to a column automatically. At this point, the automatic device was released and by using the hand wheel, the load was increased by increments of 1000 pounds; also, between each increase of load, extensometer readings were taken. When the total load on the column had reached about 40,000 pounds, the automatic device was again thrown into operation, and the load applied until the failure of the column began to take place.

The same precaution as that used in the case of the column was used to prevent the setting up of eccentric stresses in the cubes, the cubes being set on a spherical bearing block. These cubes were only tested for their ultimate strength, the load being applied by means of the automatic device.

D I S C U S S I O N.

We will consider the effect of spiral reënforcing upon the strength of columns as brought out by the results of this investigation from two points of view, namely:- That view which holds that the proper basis of the establishment of the working stress used in designing should be the elastic limit of a substance and that which points out the use of a factor of safety in connection with the ultimate strength of the column in the proper basis. Since the latter is more common, this discussion will treat at greater length those points to be brought out in this connection.

A consideration of the data on those sheets which give the summation of the results of each set of columns shows that the question of establishing the working stress upon the basis of elastic limit is quite impossible. We see that in no case, not even in the case of columns without reënforcing is it possible to determine the value of the stress at the elastic limit; the law of variation of the shortening is quite different from that of the law

of variation of steel. In all four cases we find that beginning at a certain point the difference between two consecutive unit shortenings increase until the difference has become two to five times that of the first value considered. Suddenly the value of the difference may again drop to a point somewhat below that first noticed or a trifle above. The only explanation for this, which would seem at all reasonable, may be obtained by noting the nature of the aggregate and imagining the way in which a failure may take place. When the concrete is poured into the mould probably a large number of edges of certain stones butt against the flat surfaces of the stones adjacent, the resistance of these edges varying greatly. When the load that is applied to the column is increased, these edges which at first show a slight deformation under light loads, begin to crumble until so much of the edges have been broken off that an increase of bearing surface has been obtained; this increase in bearing surface again increases the resistance to deformation; after a while the edges that heretofore could withstand the stress begin to fail, this sort of operation repeats itself, the difference

in variation of the deformation between two consecutive increments rising and falling until finally the cement band between the aggregate begins breaking down and a complete failure of the column takes place: i. e. if there is no spiral reënforcing present to prevent failure at this point in loading.

The results obtained in this investigation do not give us much knowledge as to the portion of the stress that is taken by the steel.

The only reliable statement which can be made concerning the effect of this form of reënforcing upon the point which we may consider the elastic limit of the columns is that it raised this limit an average value of 45 percent. From the data, we see that the total load which was carried by a column when the elastic limit was reached was practically the same in all cases. We note also that even from the very beginning, the columns which contained reënforcing have greater unit shortenings per unit load than is shown by the plain columns. This characteristic may be attributed to the fact that the portion of a column which is outside of the reënforcing takes only a part of the stress which

would be taken by a similar portion of a non-reënforced column: the cause of this unequal distribution of stress being that this outer cylinder is separated from the part included within the reënforcing by a cylindrical surface of weakness due to the reënforcing. Because of this, it seems reasonable to suppose that the portion of the column enclosed by reënforcing may only be considered as the truly effective portion. If then we subtract the part of the load on the column at the elastic limit which may be assumed to be taken by the cylinder and divide the remainder by the effective area of the column we will have the unit stress on the column at this limit. This stress we find to be greater than that of the plain column at the same point.

The relative effect of the various percentages of steel is practically indeterminate owing to the uncertainty of the amount of the stress taken by the cylinder of concrete under the different conditions. If we assume that in each case the cylinder takes the same amount of stress, we can show that two percent of steel is as effective as three or four percent.

On the other hand, if we assume that the stress becomes less as the percentage of steel increases because of an increased weakness in the cylindrical fault plane, we can show that the elastic limit of the columns have been increased with an increase in the percentage of steel used.

When we consider the effect of the spiral reënforcing upon the ultimate strength of a column, we find a very appreciable increase. It was found that the increase in the ultimate strength of the columns reënforced with two percent of steel above that of the columns that were without reënforcing was much greater than the increase of those with four percent over those with two percent. The data shows that the variation of the increase in the ultimate strength of the columns is directly proportional to the amount of steel used. Long before, however, the ultimate strength of the column had been reached, the cylinder of concrete between the reënforcing and the outside of the columns, cracked and fell off. It has been at this point that the extensometer readings were no longer taken and that the automatic feeding device on the Riehle machine was put into operation.

C O N C L U S I O N.

In concluding, we will repeat two points brought out in the above discussion and also suggest a slight modification of the above mentioned method of proceedure.

Unless one has been present to watch the spalling action of the outer portions of the reënforced columns he may take exception to the value which we will lay down as the approximate value of the increase of the stress at the point which we will call the elastic limit. To derive this value, we will first assume that in the case of the columns that were reënforced the total load on each column was taken by the part enclosed by the spiral. Since the reenforced column carried practically the same load as the non-reënforced at this point, we know that their respective unit stress must be inversely proportional to the cross section area of their effective portion; that is, as 162:100 or that the part which is surrounded by the spiral may be stressed 62% above that to which an equal area of plain column may be subjected before the elastic limit has been

reached. Close inspection of the cracks in the outer wall of a column when it has reached this limit makes one feel that if the above figure (62%) were reduced by 50%, the outer wall may be considered as taking even a greater load than is fair to assume. We will therefore recommend that the average value of the effect of the spiral reënforcing in increasing the resistance of the column at the elastic limit be 31%; no attempt being made here to express a relative value for the various percentage - due to the uncertainty of the action of the outer wall.

In regard to fixing a value for the increase in the ultimate strength of a column we do not feel the same hesitancy: because we can see that a complete failure takes place only after the spiral begins to snap in various places. The percentage of increase in the ultimate strength per one percent of steel is approximately 16%.

The modification which we would recommend in case this investigation would be repeated, would be to establish the elastic limit of the column not by the comparison of the successive unit shortening per unit load, but by the comparison of the amount of set the

column has received per unit length after each increase of load.

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Log Sheet for Column No. 1.

Av. Area for Total Cross Section 38.52 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 4%.
Distance between Extensometer rings 34.25 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus Dia. 7".	Modulus Dia. 5.5"
0	.856	.856	.856	.0000				
20	.842	.847	.844	.000367	519		1413000	
21	.838	.845	.841	.000450	545		1210000	
22	.836	.844	.840	.000470	571		1214000	
23	.833	.842	.837	.000543	597		1097000	
24	.830	.841	.835	.000602	622		1031000	
25	.827	.839	.833	.000675	649	1050	962000	1553000
26	.825	.837	.831	.000733	675	1090	921000	1487000
27	.822	.834	.828	.000822	700	1132	853000	1378000
28	.817	.832	.824	.000925	726	1175	785000	1272000
29	.812	.830	.821	.001026	752	1218	733000	1188000
30	.807	.827	.817	.001143	778	1260	681000	1100000
31	.803	.824	.813	.001247	805	1303	645000	1045000
32	.797	.821	.809	.001380	830	1343	618000	972000
32.5	.793	.819	.806	.001468	843	1365	575000	930000
33	.790	.816	.803	.001555	856	1387	550000	894000
33.5	.786	.814	.800	.001643	870	1408	529000	858000
34	.780	.812	.796	.001760	882	1429	507000	812000
34.5	.775	.809	.792	.001880	895	1450	476000	771000
35	.771	.806	.788	.001981	908	1470	457000	743000
35.5	.765	.804	.784	.002098	921	1491	438000	710000
36	.760	.800	.780	.002215	934	1512	422000	672000
36.5	.754	.797	.775	.002362	947	1532	400000	648000
37	.748	.794	.771	.002493	960	1553	385000	623000
37.5	.741	.791	.766	.002642	973	1573	368000	595000
38	.734	.786	.756	.002815	986	1595	350000	566000

Ultimate strength 72,950 lbs.

Ultimate unit strength 3060 lbs. per sq. in.

Log Sheet for Column No. 2.

Av. Area for Total Cross Section 38.57 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 4%.
Distance between Extensometer rings 34 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.761	.761	.761	.0000				
20	.735	.743	.739	.000647	519		803000	
21	.730	.740	.735	.000765	545		717000	
22	.728	.738	.733	.000824	571		694000	
23	.724	.735	.729	.000927	597		644000	
24	.721	.733	.727	.001000	622		622000	
25	.720	.730	.725	.001058	649	1050	612000	993000
26	.718	.727	.722	.001132	675	1090	597000	964000
27	.715	.725	.720	.001205	700	1132	581000	938000
28	.711	.719	.715	.001354	726	1175	536000	868000
29	.704	.714	.709	.001530	752	1218	492000	797000
30	.698	.710	.704	.001677	778	1260	464000	752000
31	.695	.705	.700	.001794	805	1303	449000	726000
32	.686	.702	.694	.001970	830	1343	421000	682000
32.5	.683	.699	.691	.002060	843	1365	408000	663000
33	.680	.695	.687	.002160	856	1387	396000	642000
33.5	.677	.692	.684	.002250	870	1408	387000	627000
34	.675	.688	.681	.002338	882	1429	377000	612000
34.5	.668	.686	.677	.002470	895	1450	362000	587000
35	.662	.683	.672	.002600	908	1470	349000	566000
35.5	.658	.679	.668	.002720	921	1491	338000	548000
36	.653	.675	.666	.002792	934	1512	334000	542000
36.5	.647	.669	.658	.003030	947	1532	312000	505000
37	.641	.663	.652	.003207	960	1553	309000	484000
37.5	.633	.656	.644	.003426	973	1573	284000	460000
38	.625	.648	.636	.003665	986	1595	269000	435000
38.5	.616	.640	.628	.003915	1000	1615	256000	413000
39	.606	.632	.619	.004175	1012	1637	243000	393000
39.5	.599	.623	.611	.004420	1025	1658	232000	376000
40	.591	.615	.603	.004650	1038	1680	224000	361000

Ultimate strength 69750 lbs.

Ultimate unit strength 2930 lbs. per sq. in.

Log Sheet for Column No. 3.

Av. Area for Total Cross Section 38.54 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 4%.
Distance between Extensometer Rings 34.25 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.659	.659	.659	.0000				
21	.653	.653	.653	.000175	519		2962000	
22	.648	.648	.648	.000322	545		1692000	
23	.648	.645	.646	.000365	571		1562000	
24	.647	.641	.644	.000438	597		1360000	
25	.647	.635	.641	.000526	622		1180000	
26	.645	.629	.637	.000643	649	1050	1008000	1630000
27	.645	.623	.634	.000731	675	1090	924000	1490000
28	.644	.616	.630	.000847	700	1132	828000	1335000
29	.641	.610	.625	.000978	726	1175	744000	1205000
30	.639	.601	.620	.001139	752	1218	659000	1070000
31	.637	.594	.615	.001270	778	1260	612000	993000
32	.634	.582	.608	.001490	830	1343	556000	900000
32.5	.632	.576	.604	.001608	843	1365	523000	850000
33	.630	.571	.600	.001710	856	1387	500000	812000
33.5	.627	.565	.596	.001841	870	1408	473000	766000
34	.623	.558	.590	.002000	882	1429	441000	715000
34.5	.620	.552	.586	.002130	895	1450	420000	681000
35	.618	.545	.581	.002325	908	1470	391000	632000
35.5	.614	.540	.577	.002395	921	1491	385000	622000
36	.611	.534	.572	.002528	934	1512	368000	597000
36.5	.606	.526	.566	.002718	947	1532	348000	564000
37	.596	.513	.554	.003055	960	1553	314000	509000

Ultimate strength 66520 lbs.

Ultimate unit strength 2790 lbs. per sq. in.

Log Sheet for Column No. 4.

Av. Area for Total Cross Section 38.63 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reenforcing 4%.
Distance between Extensometer Rings 33.75 in.

Load in 1000 lbs.	Extensometer Right	Left	Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Dia. 5.5"	Modulus. Dia. 7"	Dia. 5.5"
0	.591	.591	.591	.0000				
20	.584	.591	.587	.000104	519		4980000	
21	.582	.592	.587	.000120	544		4540000	
22	.580	.592	.586	.000150	570		3810000	
23	.578	.593	.585	.000163	595		5660000	
24	.575	.594	.584	.000193	620		3220000	
25	.572	.594	.583	.000237	647	1050	2735000	4430000
26	.568	.592	.580	.000326	675	1090	2070000	3350000
27	.565	.591	.578	.000385	700	1132	1816000	2940000
28	.561	.590	.575	.000460	725	1175	1575000	2560000
29	.557	.590	.573	.000518	750	1218	1450000	2350000
30	.551	.590	.570	.000608	775	1260	1280000	2072000
31	.546	.589	.567	.000697	800	1303	1154000	1870000
32	.539	.588	.563	.000815	825	1343	1180000	1643000
32.5	.535	.586	.560	.000905	840	1365	943000	1510000
33	.531	.584	.557	.000994	852	1387	860000	1395000
33.5	.526	.582	.554	.001097	865	1408	794000	1285000
34	.522	.580	.551	.001187	877	1429	743000	1204000
34.5	.517	.577	.547	.001305	890	1450	687000	1110000
35	.512	.576	.544	.001388	905	1470	654000	1058000
35.5	.507	.574	.540	.001500	915	1491	613000	954000
36	.502	.573	.537	.001587	926	1512	588000	953000
36.5	.496	.572	.534	.001692	941	1532	560000	905000
37	.490	.570	.530	.001810	952	1553	528000	854000
37.5	.483	.568	.525	.001943	965	1573	500000	810000
38	.477	.566	.521	.002002	980	1595	478000	775000
38.5	.470	.561	.515	.002240	993	1615	446000	722000
39	.460	.556	.508	.002462	1004	1637	418000	666000

Ultimate strength 80360 lbs.

Ultimate unit strength 3375 lbs. per sq. in.

Log Sheet for Column No. 5.

Av. Area for Total Cross Section 38.50 sq. in.
Av. Effective Area 38.50 sq. in.
Percentage of Reinforcing 0%.
Distance between Extensometer rings 34 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation.	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.292	.292	.292	.0000				
18	.270	.292	.281	.000324	467		1440000	
19	.269	.291	.280	.000354	493		1390000	
20	.266	.292	.279	.000383	519		1352000	
21	.265	.292	.278	.000398	545		1368000	
22	.263	.291	.277	.000442	571		1290000	
23	.263	.289	.276	.000471	597		1266000	
24	.260	.288	.274	.000530	622		1170000	
25	.257	.288	.272	.000574	649		1130000	
26	.256	.288	.272	.000588	675		1147000	
27	.253	.287	.270	.000658	700		1062000	
28	.251	.287	.269	.000677	726		1070000	
29	.250	.285	.267	.000720	752		1043000	
30	.249	.283	.266	.000765	778		1016000	
31	.245	.283	.264	.000824	805		977000	
32	.243	.283	.263	.000854	830		972000	
32.5	.243	.282	.262	.000870	843		969000	
33	.242	.282	.262	.000883	856		969000	
33.5	.241	.281	.261	.000913	870		954000	
34	.240	.281	.260	.000927	882		952000	
34.5	.239	.281	.260	.000942	895		952000	
35	.237	.280	.258	.000985	908		923000	
35.5	.236	.279	.257	.001020	921		903000	
36	.234	.278	.256	.001082	934		864000	
36.5	.230	.272	.251	.001205	947		787000	
37	.220	.261	.240	.001514	960		685000	

Ultimate strength 42250 lbs.

Ultimate strength 1095 lbs. per sq. in.

Log Sheet for Column No. 6.

Av. Area for Total Cross Section 38.46 sq. in.
Av. Effective Area 38.46 sq. in.
Percentage of Reënforcing 0%.
Distance between Extensometer rings 34.25 in.

Load in 1000 lbs.	Extensometer Right	Left	Mean	Unit Deformation.	Load Sq. Dia. 7"	per in. Dia. 5.5"	Modulus. Dia. 7"	Dia. 5.5"
0	.488	.488	.488	.000000				
20	.481	.476	.478	.000279	519		1855000	
21	.480	.474	.477	.000324	545		1680000	
22	.479	.473	.476	.000354	571		1612000	
23	.478	.471	.474	.000397	597		1500000	
24	.476	.470	.473	.000442	622		1406000	
25	.474	.468	.471	.000500	649		1300000	
26	.473	.466	.469	.000545	675		1238000	
27	.471	.463	.467	.000628	700		1113000	
28	.469	.461	.465	.000678	726		1070000	
29	.468	.459	.463	.000720	752		1043000	
30	.466	.456	.461	.000795	778		980000	
31	.465	.453	.459	.000855	805		942000	
32	.463	.449	.456	.000942	830		881000	
32.5	.462	.447	.454	.000986	843		854000	
33	.461	.445	.453	.001029	856		832000	
33.5	.460	.442	.451	.001089	870		800000	
34	.458	.439	.448	.001162	882		758000	
34.5	.456	.435	.445	.001250	895		716000	
35	.454	.430	.442	.001350	908		672000	
35.5	.451	.425	.438	.001470	921		627000	
36	.447	.420	.433	.001602	934		583000	
36.5	.444	.410	.427	.001794	947		527000	

Ultimate Strength 44,410 lbs.

Ultimate Unit Strength 1150 lbs. per sq. in.

Log Sheet for Column No. 7.

Av. Area for Total Cross Section 38.60 sq. in.
Av. Effective Area 38.60 sq. in.
Percentage of Reënforcing 0%.
Distance between Extensometer Rings 34.125 in.

Load in 1000 lbs.	Extensometer Right	Left	Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Dia. 5.5"	Modulus. Dia. 7"	Dia. 5.5"
0	.208	.208	.208	.000000				
18	.207	.206	.206	.000044	467		10600000	
19	.207	.205	.206	.000059	493		8370000	
20	.206	.206	.206	.000059	519		8800000	
21	.205	.206	.205	.000074	545		7370000	
22	.205	.206	.205	.000074	571		7720000	
23	.205	.206	.205	.000074	597		8060000	
24	.205	.205	.205	.000088	622		7080000	
25	.204	.203	.203	.000132	649		4920000	
26	.204	.202	.203	.000147	675		4590000	
27	.204	.201	.201	.000191	700		3665000	
28	.205	.199	.202	.000176	726		4125000	
29	.205	.198	.201	.000191	752		3940000	
30	.204	.198	.201	.000206	778		3775000	
31	.202	.197	.199	.000250	805		3220000	
32	.200	.196	.198	.000294	830		2825000	
32.5	.199	.195	.197	.000324	843		2600000	
33	.198	.194	.196	.000353	856		2420000	
33.5	.197	.193	.195	.000383	870		2270000	
34	.196	.190	.193	.000442	882		1991000	
34.5	.196	.188	.192	.000470	895		1905000	
35	.194	.187	.190	.000515	908		1760000	
35.5	.193	.185	.189	.000560	921		1641000	
36	.192	.184	.188	.000588	934		1587000	
36.5	.186	.180	.183	.000735	947		1287000	
37	.178	.171	.174	.000986	960		975000	

Ultimate strength 45,020 lbs.

Ultimate unit strength 1172 lbs. per sq. in.

Log Sheet Column No. 8.

Av. Area for Total Cross Section 38.55 sq. in.
Av. Effective Area 38.55 sq. in.
Percentage of Reënforcing 0%.
Distance between Extensometer rings 34.5 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.542	.542	.542	.0000				
20	.530	.541	.535	.000188	519		2760000	
21	.527	.541	.534	.000230	545		2370000	
22	.526	.542	.534	.000230	571		2480000	
23	.524	.541	.532	.000276	597		2160000	
24	.522	.540	.531	.000320	622		1941000	
25	.519	.540	.529	.000363	649		1788000	
26	.517	.539	.528	.000406	675		1660000	
27	.515	.539	.527	.000435	700		1610000	
28	.512	.538	.525	.000493	726		1472000	
29	.510	.538	.524	.000522	752		1440000	
30	.507	.537	.522	.000580	778		1340000	
31	.504	.536	.520	.000638	805		1240000	
32	.502	.536	.519	.000688	830		1208000	
32.5	.500	.535	.517	.000712	843		1182000	
33	.498	.534	.516	.000754	856		1133000	
33.5	.495	.534	.514	.000797	870		1090000	
34	.492	.532	.512	.000870	882		1012000	
34.5	.490	.531	.510	.000914	895		980000	
35	.487	.529	.508	.000977	908		931000	
35.5	.482	.526	.504	.001110	921		880000	

Ultimate strength 42,180 lbs.

Ultimate unit strength 1095 lbs. per sq. in.

Log Sheet for Column No. 9.

Av. Area for Total Cross Section 38.59 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 3%.
Distance between Extensometer Rings 33.875 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.404	.404	.404	.0000				
20	.397	.392	.394	.000281	519		1850000	
21	.396	.390	.393	.000325	545		1678000	
22	.395	.388	.391	.000396	571		1442000	
23	.393	.385	.389	.000443	597		1347000	
24	.392	.383	.387	.000487	622		1276000	
25	.390	.380	.385	.000461	649	1050	1405000	2275000
26	.388	.378	.383	.000621	675	1090	1095000	1758000
27	.385	.375	.380	.000709	700	1132	988000	1595000
28	.383	.372	.377	.000783	726	1175	928000	1500000
29	.381	.369	.375	.000857	752	1218	877000	1424000
30	.378	.365	.371	.000960	778	1260	811000	1313000
31	.376	.362	.369	.001033	805	1303	780000	1260000
32	.372	.357	.364	.001164	830	1343	713000	1158000
32.5	.370	.354	.362	.001240	843	1365	678000	1100000
33	.367	.351	.359	.001328	856	1387	645000	1045000
33.5	.363	.348	.355	.001432	870	1408	608000	984000
34	.361	.344	.352	.001520	882	1429	580000	930000
34.5	.357	.341	.349	.001625	895	1450	550000	893000
35	.352	.337	.344	.001756	908	1470	517000	838000
35.5	.347	.331	.339	.001918	921	1491	479000	777000
36	.340	.325	.332	.002140	934	1512	436000	706000
36.5	.331	.318	.324	.002346	947	1532	403000	653000

Ultimate strength 52300 lbs.

Ultimate unit strength 2192 lbs. per sq. in.

Log Sheet for Column No. 10.

Av. Area for Total Cross Section 38.49 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reinforcing 3%.
Distance between Extensometer Rings 34.5 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.942	.942	.942	.0000	0	0		
20	.920	.936	.928	.000406	519		1286000	
21	.916	.932	.924	.000522	545		1045000	
22	.914	.930	.922	.000580	571		985000	
23	.911	.927	.919	.000667	597		895000	
24	.908	.924	.916	.000754	622		835000	
25	.906	.920	.913	.000841	649	1050	772000	1245000
26	.905	.916	.910	.000914	675	1090	738000	1192000
27	.902	.913	.907	.001000	700	1132	700000	1132000
28	.897	.909	.903	.001130	726	1175	694000	1040000
29	.891	.904	.897	.001290	752	1218	582000	945000
30	.885	.900	.892	.001436	778	1260	542000	878000
31	.880	.897	.888	.001552	805	1303	518000	865000
32	.874	.891	.882	.001725	830	1343	481000	778000
32.5	.870	.887	.878	.001842	843	1365	457000	742000
33	.867	.883	.875	.001942	856	1387	441000	715000
33.5	.864	.878	.871	.002060	870	1408	422000	684000
34	.861	.873	.867	.002174	882	1429	406000	658000
34.5	.857	.868	.862	.002306	895	1450	388000	628000
35	.853	.864	.858	.002420	908	1470	375000	607000
35.5	.849	.859	.854	.002538	921	1491	362000	587000
36	.843	.854	.848	.002710	934	1512	345000	558000
36.5	.835	.846	.840	.002945	947	1532	321000	520000
37	.824	.838	.831	.003220	960	1553	298000	482000

Ultimate Strength 62350 lbs.

Ultimate unit strength 2620 lbs. per sq. in.

Log Sheet for Column No. 11.

Av. Area for Total Cross Section 38.51 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 3%.
Distance between Extensometer Rings 33,875 in.

Load in 1000 lbs.	Extensometer Right	Left	Mean	Unit Deformation	Load per Sq. in. Dia. 7"	Dia. 5.5"	Modulus. Dia. 7"	Dia. 5.5".
0	.547	.547	.547	.0000	0	0		
20	.543	.538	.540	.000192	519		2700000	
21	.542	.536	.539	.000236	545		2310000	
22	.541	.535	.538	.000266	571		2145000	
23	.540	.534	.537	.000295	597		2020000	
24	.539	.532	.536	.000310	622		2002000	
25	.538	.530	.534	.000384	649	1050	1687000	2730000
26	.536	.528	.532	.000443	675	1090	1522000	2460000
27	.533	.525	.529	.000532	700	1132	1315000	2125000
28	.531	.524	.527	.000576	726	1175	1360000	2040000
29	.529	.521	.525	.000650	752	1218	1155000	1845000
30	.526	.518	.522	.000738	778	1260	1050000	1708000
31	.523	.516	.519	.000812	805	1303	993000	1604000
32	.519	.513	.516	.000916	830	1343	908000	1465000
32.5	.516	.511	.513	.000990	843	1365	852000	1380000
33	.513	.509	.511	.001063	856	1387	805000	1304000
33.5	.509	.505	.507	.001181	870	1408	736000	1202000
34	.506	.503	.504	.001254	882	1429	703000	1140000
34.5	.502	.500	.501	.001357	895	1450	660000	1070000
35	.499	.496	.497	.001461	908	1470	622000	1005000
35.5	.495	.492	.493	.001580	921	1491	583000	944000
36	.491	.487	.489	.001713	934	1512	545000	882000
36.5	.485	.482	.483	.001875	947	1532	505000	816000
37	.476	.474	.475	.002126	960	1553	452000	730000

Ultimate strength 73870 lbs.

Ultimate unit strength 3100 lbs. per sq. in.

Log Sheet for Column No. 12.

Av. Area for Total Cross Section 38.52 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of reënforcing 3%.
Distance between Extensometer rings 33.87 in.

Load in 1000 lbs.	Extensometer			Unit Deformation.	Load per Sq. in.		Modulus.	
	Right	Left	Mean		Dia. 7".	Dia. 5.5"	Dia. 7"	Dia. 5.5"
0	.212	.212	.212	.0000				
20	.195	.205	.200	.000354	519		1467000	
21	.192	.203	.197	.000428	545		1274000	
22	.189	.202	.195	.000487	571		1172000	
23	.186	.201	.193	.000547	597		1090000	
24	.182	.199	.190	.000635	622		950000	
25	.179	.197	.188	.000709	649	1050	916000	1481000
26	.177	.195	.186	.000767	675	1090	880000	1424000
27	.174	.194	.184	.000827	700	1132	841000	1372000
28	.169	.192	.180	.000930	726	1175	781000	1265000
29	.163	.189	.176	.001063	752	1218	707000	1145000
30	.158	.186	.172	.001180	778	1260	658000	1068000
31	.154	.183	.168	.001283	805	1303	627000	1015000
32	.148	.179	.163	.001432	830	1343	580000	939000
32.5	.144	.175	.159	.001550	843	1365	544000	882000
33	.141	.171	.156	.001653	856	1387	517000	840000
33.5	.138	.167	.152	.001757	870	1408	495000	802000
34	.135	.164	.149	.001844	882	1429	478000	775000
34.5	.131	.161	.146	.001948	895	1450	459000	744000
35	.127	.155	.141	.002094	908	1470	433000	702000
35.5	.123	.151	.137	.002213	921	1491	416000	674000
36	.119	.146	.132	.002347	934	1512	397000	644000
36.6	.113	.141	.127	.002510	947	1532	377000	610000
37	.109	.135	.122	.002658	960	1553	361000	585000
37.5	.101	.127	.114	.002890	973	1573	337000	545000
38	.92	.120	.106	.003130	986	1595	315000	510000
38.5	.81	.112	.0965	.003410	1000	1615	293000	473000

Ultimate strength 63,280 lbs.

Ultimate strength 2680 lbs. per sq. in.

Log Sheet for Column No. 13.

Av. Area for Total Cross Section 38.56 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 2%.
Distance between Extensometer Rings 34 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation.	Load per Sq. in. Dia. 7"	Load per Sq. in. Dia. 5.5"	Modulus. Dia. 7".	Modulus. Dia. 5.5"
0	.717	.717	.717	.0000				
20	.707	.711	.709	.000235	519		2043000	
21	.705	.709	.707	.000294	545		1862000	
22	.703	.709	.706	.000324	571		1762000	
23	.701	.708	.704	.000368	597		1620000	
24	.699	.706	.702	.000426	622		1459000	
25	.696	.704	.700	.000500	649	1050	1298000	2100000
26	.693	.703	.698	.000559	675	1090	1208000	1950000
27	.690	.702	.696	.000618	700	1132	1132000,	1833000
28	.684	.700	.692	.000781	726	1175	930000	1505000
29	.682	.699	.690	.000779	752	1218	966000	1564000
30	.679	.697	.688	.000853	778	1260	913000	1475000
31	.675	.695	.685	.000941	805	1303	856000	1385000
32	.670	.694	.682	.001029	830	1343	807000	1305000
32.5	.667	.693	.680	.001088	843	1365	775000	1254000
33	.665	.691	.678	.001146	856	1387	741000	1210000
33.5	.662	.690	.676	.001205	870	1408	722000	1170000
34	.659	.688	.673	.001280	882	1429	688000	1116000
34.5	.655	.686	.670	.001368	895	1450	653000	1060000
35	.651	.683	.667	.001470	908	1470	617000	1000000
35.5	.646	.680	.663	.001587	921	1491	580000	938000
36. 5	.640	.676	.658	.001735	934	1512	538000	871000
37	.633	.670	.651	.001915	947	1532	494000	800000
37.5	.629	.665	.647	.002058	960	1553	466000	765000
38	.619	.657	.638	.002321	973	1573	419000	678000

Ultimate strength 57340 lbs.

Ultimate unit strength 2410 lbs. per sq. in.

Log Sheet for Column No. 14.

Av. Area for Total Cross Section 38.58 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 2%.
Distance between Extensometer Rings 34 in.

Load in 1000 lbs.	Extensometer Right	Left	Mean	Unit Deformation	Load per Sq. in. Dia. 7".	Dia. 5.5"	Modulus. Dia. 7".	Dia. 5.5"
0	.697	.697	.697	.0000				
20	.683	.686	.684	.000368	519		1410000	
21	.679	.685	.682	.000441	545		1235000	
22	.677	.684	.680	.000486	571		1172000	
23	.674	.683	.678	.000544	597		1095000	
24	.671	.681	.676	.000618	622		1004000	
25	.668	.679	.673	.000642	649	1050	1006000	1635000
26	.665	.677	.671	.000765	675	1090	884000	1425000
27	.662	.676	.669	.000824	700	1132	850000	1370000
28	.858	.675	.666	.000897	726	1175	810000	1310000
29	.654	.674	.664	.000971	752	1218	775000	1203000
30	.649	.673	.661	.001058	778	1260	735000	1190000
31	.646	.671	.658	.001130	805	1303	712000	1150000
32	.640	.670	.655	.001235	830	1343	672000	1085000
32.5	.636	.668	.652	.001323	843	1365	633000	1032000
33	.632	.667	.649	.001396	856	1387	613000	995000
33.5	.628	.667	.646	.001485	870	1408	586000	949000
34	.624	.666	.645	.001530	882	1429	577000	934000
34.5	.620	.665	.642	.001604	895	1450	558000	904000
35	.615	.664	.639	.001690	908	1470	537000	868000
35.5	.611	.663	.637	.001765	921	1491	521000	844000
36	.607	.661	.634	.001853	934	1512	505000	816000
36.5	.602	.659	.630	.001955	947	1532	484000	783000
37	.597	.657	.627	.002060	960	1553	466000	754000
37.5	.591	.655	.623	.002175	973	1573	447000	723000
38	.582	.652	.617	.002350	986	1595	419000	680000
38.5	.571	.647	.609	.002590	1000	1615	387000	625000

Ultimate strength 64300 lbs.

Ultimate unit strength 2700 lbs. per sq. in.

Log Sheet for Column No. 15.

Av. Area for Total Cross Section 38.52 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 2%.
Distance between Extensometer Rings 34.125 in.

Load in 1000 lbs.	Extensometer Right	Extensometer Left	Extensometer Mean	Unit Deformation	Load per Sq. in., Dia. 7"	Load per Sq. in., Dia. 5.5"	Modulus. Dia. 7"	Modulus. Dia. 5.5"
0	.688	.688	.688	.0000				
20	.677	.680	.678	.000278	519		1868000	
21	.676	.678	.677	.000322	545		1692000	
22	.675	.677	.676	.000352	571		1623000	
23	.675	.675	.675	.000381	597		1566000	
24	.673	.675	.674	.000411	622		1510000	
25	.672	.673	.672	.000455	649	1050	1422000	2510000
26	.670	.671	.670	.000513	675	1090	1325000	2125000
27	.668	.668	.668	.000587	700	1132	1190000	1927000
28	.668	.664	.666	.000645	726	1175	1125000	1820000
29	.666	.662	.664	.000704	752	1218	1065000	1620000
30	.665	.659	.662	.000762	778	1260	1020000	1508000
31	.663	.656	.659	.000836	805	1303	964000	1500000
32	.661	.652	.656	.000924	830	1343	898000	1451000
32.5	.660	.649	.654	.000982	843	1365	860000	1392000
33	.658	.647	.652	.001040	856	1387	832000	1335000
33.5	.657	.645	.651	.001083	870	1408	804000	1304000
34	.655	.643	.649	.001142	882	1429	771000	1251000
34.5	.653	.640	.646	.001216	895	1450	735000	1194000
35	.652	.638	.645	.001260	908	1470	720000	1165000
35.5	..651	.635	.643	.001320	921	1491	698000	1130000
36	.649	.631	.640	.001407	934	1512	663000	1074000
36.5	.647	.625	.636	.001524	947	1532	620000	1005000
37	.645	.621	.633	.001613	960	1553	595000	963000
37.5	.642	.617	.629	.001715	973	1573	567000	917000
38	.638	.611	.624	.001860	986	1595	530000	857000

Ultimate strength 51620 lbs.

Ultimate unit strength 2165 lbs. per sq. in.

Log Sheet for Column No. 16.

Av. Area for Total Cross Section 38.47 sq. in.
Av. Effective Area 23.8 sq. in.
Percentage of Reënforcing 2%.
Distance between Extensometer rings 34.375 in.

Load in 1000 lbs.	Extensometer			Unit Deformation	Load per Sq. in.		Modulus.	
	Right	Left	Mean		Dia. 7"	Dia. 5.5"	Dia. 7"	Dia. 5.5"
0	.656	.656	.656	.0000	0	0		
20	.644	.647	.645	.000306	520		1695000	
21	.642	.645	.643	.000364	546		1496000	
22	.640	.644	.642	.000407	573		1403000	
23	.638	.641	.639	.000480	600		1243000	
24	.635	.640	.637	.000538	625		1153000	
25	.632	.637	.634	.000626	650	1050	1032000	1675000
26	.628	.635	.631	.000713	676	1090	948000	1530000
27	.626	.632	.629	.000786	703	1132	891000	1437000
28	.623	.629	.626	.000874	729	1175	881000	1345000
29	.620	.626	.623	.000961	755	1218	783000	1112000
30	.616	.623	.619	.001062	782	1260	731000	1107000
31	.613	.619	.616	.001164	809	1303	692000	1100000
32	.609	.615	.612	.001282	834	1343	647000	1045000
32.5	.604	.611	.607	.001414	847	1365	595000	965000
33	.600	.608	.604	.001515	860	1387	565000	916000
33.5	.595	.605	.600	.001633	875	1408	533000	863000
34	.591	.602	.596	.001735	886	1429	508000	825000
34.5	.487	.598	.592	.001850	900	1450	484000	784000
35	.483	.594	.588	.001968	913	1470	462000	747000
35.5	.478	.590	.584	.002100	926	1491	438000	710000
36	.471	.586	.578	.002260	939	1512	413000	668000
36.5	.465	.579	.572	.002448	952	1532	386000	625000
37	.457	.572	.564	.002667	965	1553	360000	582000

Ultimate strength 61710 lbs.

Ultimate unit strength 2690 lbs. per sq. in.

REENFORCING 0%.

Load in 1000 lbs.	Unit Deformation					Unit Load		Modulus.	
	Col. 7	Col. 6	Col. 8	Col. 5	Mean	7"	5.5"	7"	5.5"
0	0	0	0	0	0	0	0	0	0
20	.000059	.000279	.000188	.000383	.000227	519		2280000	
21	.000074	.000324	.000230	.000398	.000256	545		2125000	
22	.000074	.000354	.000230	.000442	.000275	571		2070000	
23	.000074	.000397	.000276	.000471	.000305	597		1955000	
24	.000088	.000442	.000320	.000530	.000345	622		1800000	
25	.000132	.000500	.000363	.000574	.000392	649		1654000	
26	.000147	.000545	.000406	.000588	.000447	675		1510000	
27	.000191	.000628	.000435	.000658	.000478	700		1462000	
28	.000176	.000678	.000493	.000678	.000506	726		1435000	
29	.000191	.000720	.000522	.000720	.000538	752		1396000	
30	.000206	.000795	.000580	.000765	.000586	778		1326000	
31	.000250	.000855	.000638	.000824	.000642	805		1254000	
32	.000294	.000942	.000688	.000854	.000694	830		1195000	
32.5	.000324	.000986	.000712	.000870	.000723	843		1164000	
33	.000353	.001029	.000754	.000883	.000755	856		1132000	
33.5	.000383	.001089	.000797	.000913	.000795	870		1093000	
34	.000442	.001162	.000870	.000927	.000850	882		1037000	
34.5	.000470	.001250	.000914	.000942	.000894	895		1000000	
35	.000515	.001350	.000977	.000985	.000957	908		950000	
35.5	.000560	.001470	.001110	.001020	.001040	921		885000	
36	.000588	.001602		.001082	.001061	934		881000	
36.5	.000735	.001794		.001205	.001245	947		761000	
37	.000986			.001514	.001250	960		768000	

REENFORCING 2%.

Load in 1000 lbs.	Unit Deformation					Unit Load		Modulus.	
	Col.16	Col.14	Col.15	Col.13	Mean	7"	5.5"	7"	5.5"
0	0	0	0	0	0	0		0	
20	.000306	.000368	.000278	.000235	.000297	519		1745000	
21	.000364	.000441	.000322	.000324	.000363	545		1500000	
22	.000407	.000486	.000352	.000368	.000403	571		1415000	
23	.000480	.000544	.000381	.000426	.000458	597		1303000	
24	.000538	.000618	.000411	.000500	.000517	622		1200000	
25	.000626	.000642	.000455	.000559	.000570	649	1050	1137000	2035000
26	.000713	.000765	.000513	.000618	.000652	675	1090	1035000	1673000
27	.000786	.000824	.000587	.000781	.000744	700	1132	940000	1522000
28	.000874	.000897	.000645	.000779	.000799	726	1175	908000	1470000
29	.000961	.000971	.000704	.000853	.000872	752	1218	863000	1396000
30	.001062	.001058	.000762	.000941	.000956	778	1260	814000	1317000
31	.001164	.001130	.000836	.001029	.001040	805	1303	773000	1250000
32	.001282	.001235	.000924	.001088	.001132	830	1343	733000	1188000
32.5	.001414	.001323	.000982	.001146	.001216	843	1365	694000	1124000
33	.001515	.001396	.001040	.001205	.001289	856	1387	664000	1075000
33.5	.001633	.001485	.001083	.001280	.001370	870	1408	635000	1026000
34	.001735	.001530	.001142	.001368	.001444	882	1429	612000	990000
34.5	.001850	.001604	.001216	.001470	.001535	895	1450	583000	945000
35	.001968	.001690	.001260	.001587	.001626	908	1470	558000	905000
35.5	.002100	.001765	.001320	.001735	.001730	921	1491	532000	863000
36	.002260	.001853	.001407	.001915	.001859	934	1512	502000	813000
36.5	.002448	.001955	.001524	.002058	.001996	947	1532	475000	768000
37	.002667	.002060	.001613	.002321	.002165	960	1553	443000	718000
37.5	.	.002175	.001715		.001945	973	1573	500000	808000
38		.002350	.001860		.002105	986	1595	468000	757000
38.5		.002590			.002590	1000	1615	387000	624000

REENFORCING 3%.

Load in 1000 lbs.	Unit Deformation					Unit Load		Modulus.	
	Col. 9	Col.10	Col.11	Col.12	Mean	7"	5.5"	7"	5.5"
0	0	0	0	0	0	0	0	0	0
20	.000281	.000406	.000192	.000354	.000308	519		1683000	
21	.000325	.000522	.000236	.000428	.000378	545		1410000	
22	.000396	.000580	.000266	.000487	.000432	571		1320000	
23	.000443	.000667	.000295	.000547	.000488	597		1223000	
24	.000487	.000754	.000310	.000635	.000546	622		1137000	
25	.000461	.000841	.000384	.000709	.000599	649	1050	1082000	1754000
26	.000621	.000914	.000443	.000767	.000686	675	1090	985000	1590000
27	.000709	.001000	.000532	.000827	.000780	700	1132	897000	1453000
28	.000783	.001130	.000576	.000930	.000854	726	1175	850000	1375000
29	.000857	.001290	.000650	.001063	.000965	752	1218	780000	1263000
30	.000960	.001436	.000738	.001180	.001078	778	1260	722000	1167000
31	.001033	.001552	.000812	.001283	.001170	805	1303	688000	1113000
32	.001164	.001725	.000916	.001432	.001310	830	1343	633000	1025000
32.5	.001240	.001842	.000990	.001550	.001405	843	1365	600000	974000
33	.001328	.001942	.001063	.001653	.001496	856	1387	572000	929000
33.5	.001432	.002060	.001181	.001757	.001608	870	1408	541000	876000
34.	.001520	.002174	.001254	.001844	.001698	882	1429	520000	844000
34.5	.001625	.002306	.001357	.001948	.001809	895	1450	494000	802000
35	.001756	.002420	.001461	.002094	.001933	908	1470	470000	762000
35.5	.001918	.002538	.001580	.002213	.002137	921	1491	451000	698000
36	.002140	.002710	.001713	.002347	.002227	934	1512	419000	680000
36.5	.002346	.002945	.001875	.002510	.002419	947	1532	391000	634000
37	.	.003220	.002126	.002658	.002668	960	1553	360000	587000
37.5				.002890	.002890	973	1573	337000	544000
38				.003130	.003130	986	1595	315000	510000
38.5				.003410	.003410	1000	1615	294000	475000

REENFORCING 4%.

Load in 1000 lbs.	Unit Deformation					Unit Load		Modulus.	
	Col. 3	Col. 2	Col. 4	Col. 1	Mean	7"	5.5"	7"	5.5"
0	0	0	0	0	0	0	0	00	0
20	.000175	.000647	.000104	.000367	.000324	519		1600000	
21	.000322	.000765	.000120	.000450	.000414	545		1317000	
22	.000365	.000824	.000150	.000470	.000452	571		1260000	
23	.000438	.000927	.000163	.000543	.000518	597		1150000	
24	.000526	.001000	.000193	.000602	.000580	622		1070000	
25	.000643	.001058	.000237	.000675	.000653	649	1050	990000	1610000
26	.000731	.001132	.000326	.000733	.000730	675	1090	925000	1492000
27	.000847	.001205	.000385	.000822	.000815	700	1132	860000	1390000
28	.000978	.001354	.000460	.000925	.000929	726	1175	783000	1263000
29	.001139	.001530	.000518	.001026	.001053	752	1218	714000	1158000
30	.001270	.001677	.000608	.001143	.001177	778	1260	662000	1070000
31	.001490	.001794	.000697	.001247	.001307	805	1303	616000	997000
32	.001608	.001970	.000815	.001380	.001443	830	1343	575000	933000
32.5	.001710	.002060	.000905	.001468	.001546	843	1365	545000	885000
33	.001841	.002160	.000994	.001555	.001662	856	1387	515000	836000
33.5	.002000	.002250	.001097	.001643	.001748	870	1408	498000	806000
34	.002130	.002338	.001187	.001760	.001854	882	1429	475000	772000
34.5	.002325	.002470	.001305	.001880	.001995	895	1450	448000	727000
35	.002395	.002600	.001388	.001981	.002091	908	1470	434000	704000
35.5	.002538	.002720	.001500	.002098	.002214	921	1491	416000	673000
36	.002718	.002792	.001587	.002215	.002428	934	1512	384000	622000
36.5	.003055	.003030	.001692	.002362	.002545	947	1532	372000	602000
37	.	.003207	.001810	.002493	.002503	960	1553	383000	620000
37.5		.003426	.001943	.002642	.002670	973	1573	365000	595000
38		.003665	.002062	.002815	.002847	986	1595	346000	560000
38.5		.003915	.002240		.003078	1000	1615	324000	525000
39		.004175	.002462		.003319	1012	1631	305000	492000
39.5		.004420			.004420	1025	1652	232000	374000
40		.004650			.004650	1048	1675	225000	360000

TEST OF CUBES.

Cube No.	Dimensions	Cross Section	Load	Unit Load.
CUBES FOR PLAIN REENFORCED COLUMNS.				
1.	5.96" x 5.95"	35.45 sq. in.	55250	1558
2.	6.00" x 5.95"	35.70 sq. in.	55190	1544
CUBES FOR 2% REENFORCED COLUMNS.				
3.	5.98" x 6.01"	35.90 sq. in	57760	1603
4.	5.99" x 5.95"	35.66 sq. in.	54800	1535
CUBES FOR 3% REENFORCED COLUMNS.				
5.	6.00" x 5.96"	35.75 sq. in.	56480	1572
6.	6.00" x 6.00"	36.00 sq. in.	58020	1610
CUBES FOR 4% REENFORCED COLUMNS.				
7.	5.97" x 5.94"	35.43 sq. in.	59250	1670
8.	5.97" x 5.98"	35.70 sq. in.	58170	1627

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